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Title: Student Acceptance of Tablet Devices in Secondary Education: A three-wave longitudinal cross-lagged case study

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Abstract: As ICT is increasingly permeating all aspects of everyday life, it is apparent that education cannot leap behind. In this article we longitudinally investigate a much-debated obligatory full-scale implementation of tablet devices in a large secondary school. We adopt a Theory of Planned Behavior (TPB) approach to verify the dynamic nature of students' acceptance of the tablet as a learning tool at three waves of data collection, both at pre- and short and long-term post-adoption stages. The results clearly indicate the evolutionary nature of the acceptance process, challenging the adequacy of cross-sectional approaches to technology adoption. In the pre-adoption stage, attitude appears as a key uptake factor, whereas three months later, due to practical and technical constraints, the attention shifts to subjective norm and perceived behavioral control. Finally, six months after introduction indicative traces of habituation appear, raising concerns on the suitability of the TPB in established post-adoption circumstances.

January 6th, 2014

Dear Editor(s),

Please find attached the revised manuscript "Student Acceptance of Tablet Devices in Secondary Education: A three-wave longitudinal cross-lagged case study". This study draws upon the Theory of Planned Behaviour to design a cross-lagged longitudinal study that addresses the over-time interplay between pre- and post-adoption key uptake factors, i.e. attitude, subjective norm, and perceived behavioural control.

We have taken into account and have responded to all of the reviewer comments, as requested in the decision e-mail. We elaborate on these issues in the rebuttal, which is part of the current manuscript.

We declare that this manuscript has not been published previously and that it is not under consideration for publication elsewhere. In addition, we assure that all authors have fully participated in the research and the article preparation and both of us have approved the submission.

Looking forward to the results and feedback of the review procedure.

Yours sincerely,
Cédric Courtois, PhD

Dear editor(s),
Dear reviewers,

First of all, we insist on thanking you for the time you have invested in providing feedback on the manuscript and allowing for the opportunity to submit a revised version. Your helpful comments have led to multiple modifications that are outlined one-by-one below.

Reviewer 1

Comment: "Page 7, line #5: (This is H1) here the word "wave" is used. It is explained later on in the text, but it would be helpful to explain it here where the word is used first."

Response: The concept of wave is now explained in the introduction: "Three research waves, i.e. distinct moments of data collection, are analyzed: the pre-adoption expectation in September 2012, followed by post-adoption experiences measured at November 2012 and March 2013."

Comment: "With regard to hypotheses 5, in particular 5b, I was a bit puzzled about the following. The authors assume a positive correlation between the sensed strength of the subjective norm and positive attitude. But sensed strength says something about the strength of the subjective norm, but nothing about its directedness. In other words, there can also be a strong, but negative, subjective norm. From my own experience with implementing electronic learning environments in schools I know that some teachers are very positive about educational technology, some can be very negative. The negative ones might also strongly influence the attitudes of the students, but in an opposite direction. Did the authors have any (perhaps informal) cues that teachers/board were generally positive?"

Response: You are absolutely right that in case of strong resistance among the teachers, pressing hard on the acceptance might lead to adverse results (i.e. a negative attitude). However, as teacher support in the studied school was imperative prior to the decision to adopt tablets on a one-to-one scale, we added a section in the paper arguing that a positive association is the most likely of both possibilities:

"For instance, a study employing the TAM model found that earlier measures of subjective norm positively explain future attitudes, and vice versa, after controlling for measurement stability (Sivo et al., 2004). It appears that a positive attitude at one point renders students more susceptible to social influence, while a feeling of social influence also predicts an onwards-positive attitude. The former is likely due to a confirmation bias, i.e. the tendency to mainly select and be attentive of belief-confirming information (Nickerson, 1998). When a positive attitude is maintained, confirming information is more positively appraised. On the other hand, the reverse

hypothesis hints that positively oriented teachers, together with the school board, would pass this belief on to the students. Although it is most unlikely that all teachers welcome the tablet device to an equal extent, it must be noted that before taking the decision to take the leap into implementation, wide support at teacher level was a prerequisite. Hence, we presume that the general teacher position to and communication concerning the school-wide adoption was generally neutral to favorable. Still, in literature, it is assumed that in the first stages of (forced) adoption, subjective norm has a much stronger influence on the uptake than later on (Venkatesh & Morris, 2000). If the technology performs well, like peers and superiors advocated, it is much more likely that these experience-matching beliefs are internalized."

Moreover, in stating our hypotheses, we are inspired by previous research by Sivo et al. (2004), who too found a positive association between a stronger subjective norm and a positive attitude.

Comment: "Page 13, line #7 (last line of first paragraph): Reference is made to an appendix, but this appendix is missing. Please add."

Response: This was indeed an unfortunate mistake. The revised version has the appendix section with the questionnaire items included.

Comment: "Page 14, line #5-#22 (see also Page 18, line #53 (last paragraph): This is about the extent to which attitude explains variance in usage. But "use" remains a bit vague. It would be helpful if more information is provided about the actual use of the tablets in the curriculum, that is how they were used, for which activities and possibly the extent of this usage. For example, how often were the tablets used? And for what duration? (just a rough estimate will suffice, perhaps a percentage of the total time of the curriculum). Were the tablets used all the time, in all courses, or only every now and then? For which activities were the tablets used (as an e-book? for note taking? educational apps?). Did the measurement of actual use make a distinction between use for learning purposes and use for entertainment purposes? There are many factors that can contribute to usage. Please explain "use". Perhaps, displaying the items used to measure actual use could clarify this point to the readership."

Response: The extent of use is now made more explicit. First of all, the appendix section enumerates the items used, indicating the scope of the inquired use. Second, in the methods/procedure section, we added the following explanatory text:

"It is important to keep in mind that the adoption of tablet devices in the studied school was organized with the goal to absolutely minimize the use of paper textbooks and exercise sheets in favor of digital ones. Moreover, next to a digital learning environment, various add-on interactive applications were introduced in the classrooms. Hence, the reach and consequences for everyday class practices of this

radical innovation should be deemed substantial, as these devices are used in every class for a broad diversity of tasks throughout the entire day."

Comment: "Page 21, line #41-42: "conceptual?" remove question mark"

Response: This is corrected in the current version.

Comment: "Page 22, the list of references is displayed two times (starts on page 22, starts again on page 27)"

Response: This is corrected in the current version.

Reviewer 2

Comment: "The study adopted a Theory of Planned Behavior approach to model students' acceptance of the personal tablet device as a learning tool. The author(s) reviewed related literature well to justify their research questions, and the methodology of the study was based on survey research methods in a reasonable way. Furthermore, the author(s) tried to discuss the research results comprehensively. Overall, the methodology of the study is solid and the quality of the paper is well written. However, concerning the innovative feature of the studies "Computers in Human Behavior" usually selects, this study may be plain and bring little new information to readers in the field. The study used TPB as the framework to answer their research questions. For readers in the field, the study may lack interesting points to learn from."

Response: We understand the reservation. However, as tablets in education are considered an important game-changing innovation; a prelude to how our youth might get socialized in technology appropriation, we believe as such that it is worthwhile studying. Moreover, this study, on contrast to others in the field, open the possibility for future meta-analysis, offering an overview of what technologies are well-accepted for what reasons, as opposed to possibly different outcomes. Moreover – and this is of the utmost importance, we would like to emphasize that the revised manuscript as soon as in the abstract now – and this has changed substantially in both introduction and discussion – explicitly stresses the necessity and theoretical/conceptual merits of a longitudinal approach in technology adoption research, as opposed to commonplace cross-sectional applications of the TPB. As such, it is not yet another TPB study as there are perhaps too many with limited conceptual/methodological appeal.

More specifically, beyond the subject matter of tablets in education, we raise the following points of attention we believe are of interest for a general readership in the domain of the human-computer nexus:

- Technology adoption is a dynamic, not a static process. It requires strategic research planning, carefully selection moments of data collection: in our specific case, we argue for and demonstrate pre-adoption, and short-term and long term post-adoption as valuable sense-making sample moments.
- Failing to adopt a longitudinal approach renders research susceptible for considerable bias: our results show an evolutionary pattern, tied to each of the pre/post-adoption phases. In most studies, there is no clear rationale for selecting one or the other, especially in post-adoption. As we demonstrate, after six months, the TPB building blocks hardly explain any variance beyond prior use, indicating a habituation. A one-shot study at this point would likely lead to invalid interpretations (i.e. effects of the TPB measures, although these would be cancelled out by previous experience). This is also conceptually very important: post-adoption research should include proper measures of habit, as the habit-goal interface becomes much more relevant that the conscious factors that are included in the standard TPB framework. For that reason, we explicitly refer to psychological work on the habit-goal interface.
- We also raise explicit awareness for the underestimated issue of attrition, which as we argue cannot be ignored in longitudinal technology adoption research. We demonstrate that those with a prior negative point of view are more likely to abandon the study, which has implications for the overall interpretation of results. This is the case in our study, but most likely also holds up for future studies.

In light of these revisions, we sincerely hope they address your previous concerns, rendering the current manuscript suitable for publication in Computers in Human Behavior.

Yours sincerely,
The author(s)

Highlights:

- Uses Theory of Planned behavior to model pre/post-adoption of tablets in education
- Demonstrates value of longitudinal cross-lagged analysis in technology acceptance
- Design appears methodologically appropriate frame, sensing key uptake factors
- Shows over-time interplay of attitude, subjective norm and perceived behavioral control

*Title Page with Author details

Student Acceptance of Tablet Devices in Secondary Education:

A three-wave longitudinal cross-lagged case study

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Student Acceptance of Tablet Devices in Secondary Education:

A three-wave longitudinal cross-lagged case study

Abstract

As ICT is increasingly permeating all aspects of everyday life, it is apparent that education cannot leap behind. In this article we longitudinally investigate a much-debated obligatory full-scale implementation of tablet devices in a large secondary school. We adopt a Theory of Planned Behavior (TPB) approach to verify the dynamic nature of students' acceptance of the tablet as a learning tool at three waves of data collection, both at pre- and short and long-term post-adoption stages. The results clearly indicate the evolutionary nature of the acceptance process, challenging the adequacy of cross-sectional approaches to technology adoption. In the pre-adoption stage, attitude appears as a key uptake factor, whereas three months later, due to practical and technical constraints, the attention shifts to subjective norm and perceived behavioral control. Finally, six months after introduction indicative traces of habituation appear, raising concerns on the suitability of the TPB in established post-adoption circumstances.

Introduction

In today's information society, the attainment of digital proficiency is an absolute prerequisite. Not surprisingly, the use of digital technologies is high on the educational (research) agenda, especially because of their commonly supposed potential in affording dynamic and individualized learning support. After all, we cannot ignore the widespread diffusion of information- and communication technologies in young people's everyday lives, paired with the relatively limited

appropriation of such technologies in classrooms. Still, the fruitful implementation of digital learning tools, overcoming this chasm, remains a difficult issue. Recently, debate has sparked on the potential of tablet devices as educational means (Peluso, 2012). While in public discussions proponents praise the supposed motivating character of tablet technologies, fuelled by the many easily accessible affordances they potentially offer (Alvarez, Brown, & Nussbaum, 2011; F. Ferrer, Belvis, & Pamies, 2011; Henderson & Yeow, 2012), critics however frame it as a too expensive and inefficient manifestation of technological determinism, inspired by the alleged hype-factor that dominates the discourse on the issue. Such concerns not only surface in mainstream opinion and press coverage, but also in academic literature (e.g. Ifenthaler & Schweinbenz, 2013).

In this article, we aim to subscribe and contribute to this debate by focusing on the important issue of user acceptance, not in the least by the most important stakeholders, i.e. the students themselves. After all, before the crucial assessment of potential learning effects, it is imperative to verify whether there is a bottom-up support for a continued implementation of such devices in secondary schools. Hence, the present study involves a longitudinal analysis of the acceptance process – both pre and post-launch – of the tablet as a learning tool in a relatively large Belgian secondary school that decided for a full-scale personal implementation of the tablet for all of its students and teachers. In this article, we abandon one-shot applications of user acceptance models by embracing a longitudinal approach, as also considered problematic by Sivo, Pan, and Brophy (2004). Despite calls to make this a common practice, most research efforts focus on cross-sectional inquiries. Drawing upon this study, we argue and demonstrate that this can be misleading, and that there is an apparent need to adopt a longitudinal approach that combines both pre-adoption

uptake determinants, as well as both short term and long term follow-up measures. As such, we are able to model over-time changes, which allows getting hold of the possible stability or dynamic interplay of uptake factors and how they develop through time. Three research waves, i.e. distinct moments of data collection, are analyzed: the pre-adoption expectation in September 2012, followed by post-adoption experiences measured at November 2012 and March 2013.

To do so, this study is based on the Theory of Planned Behavior (TPB) as a guiding framework (Ajzen, 1991; Montaño & Kasprzyk, 2008; Taylor & Todd, 1995). TPB, incorporating the elements of attitude, subjective norm, and perceived behavioral control to explain use (intention), is especially relevant to model technology acceptance in constrained environments. This was the case at the studied school, as students had no choice whether to adopt, which was in itself a ground for debate.

Theory of Planned Behavior: origins and form

The Theory of Planned Behavior (TPB) is a seminal theory connecting belief systems with actual behavior, aiming at its explanation and even prediction (Ajzen, 1991). It has a rich history, having its origins in other prior theories. Most important though, is its roots in the Theory of Reasoned Action (Montaño & Kasprzyk, 2008; TRA). This theory aims to explain voluntary behavior, based on a conscious decision of the actor. Basically, TRA envisions behavior as a function of behavioral intention, which is in turn based upon positive relations with the interface of attitude and subjective norm. The former element refers to affective responses, i.e. a positive or negative stance, towards performing certain behavior. The substrate of an attitude is the beliefs held towards the behavioral outcomes and the extent to which these are valued. Subjective norm comprises how significant others feel about the actor's

behavior, as perceived by that actor. Of course, the motivation to comply with these persons is of equal importance. In information systems research, TRA has been adapted to what is called the Technology Acceptance Model (TAM), which was initially composed by explanatory elements such as perceived ease of use and perceived usefulness (Davis, 1989; Legris, Ingham, & Collerette, 2003), and later on supplemented – among other constructs – with subjective norm (Schepers & Wetzels, 2007).

TPB adds to TRA by incorporating perceived behavioral control, which is relevant in situations in which the actor might not have complete volitional control over the situation at hand. It involves possible facilitators or barriers that might aid or endanger posing the behavior. Again, this is a function of perception of control attributes and the importance of possessing these attributes.

The literature counts various applications of TRA, TAM, and TPB in educational research on technology acceptance. Still, most of these studies focus on teachers, rather than students (cf. infra). It could be considered somewhat odd to leave these primary stakeholders out of the equation. Hence in this study, we explicitly focus on student acceptance of using tablet devices for school on a day-to-day basis.

In most studies, attitudinal factors have shown relatively consistent in explaining either intention or actual use. For example, direct effects of teachers' attitude were found on the usage (intention) of technology-supported teaching (Hu, Clark, & Ma, 2003), learning management systems (De Smet, Bourgonjon, De Wever, Schellens, & Valcke, 2012), web-based learning (Gong, Xu, & Yu, 2004), and digital games in the classroom (De Grove, Bourgonjon, & Van Looy, 2012). Research on learners of variable ages revealed a similar pattern, for instance on the topic of taking e-learning courses (Liu, Chen, Sun, Wible, & Kuo, 2010; Park, 2009), the

preference for having video games in class (Bourgonjon, Valcke, Soetaert, & Schellens, 2010), and – importantly – also adopting tablet computers (El-Gayar & Moran, 2007; Moran, Hawkes, & El-Gayar, 2010), albeit in a university setting.

Evidently, in this study, we expect equally robust findings and therefore propose the following first hypothesis (See Figure 1 for all hypotheses):

H1: Attitude positively explains use intention and actual use at each wave.

The second construct we include in our conceptual model is subjective norm, comprising the extent to which socially relevant actors approve or disapprove embracing the innovation in question. The assumption is that when we perceive others in favor of performing specific behavior, we will feel urged to do so on the condition that these social actors' opinions are substantially valued (Ajzen, 1991; Montaño & Kasprzyk, 2008). These influences can have various origins, not only by peers who are considered alike, but also by superiors who might have a more stringent role. In this specific article, we focus on the latter given the involuntary nature of the uptake of tablets in the school under scrutiny. Consequently, we opt to consider teachers and the school board as focal social drivers. Interestingly, there is a seeming scarcity in studies on learners' sense of subjective norm, affecting the uptake of technological innovation in education. Nevertheless, we take into account this notion, especially because of the high feasibility of such an effect, given the contested implementation in the studied school. In other words, it is plausible that students feel obliged to use the tablet, rather than out of free will.

< Insert Figure 1 about here >

H2: Subjective norm positively explains use intention and actual use at each wave.

Thirdly, perceived behavioral control is added to the conceptual model. This comprises control beliefs that are potentially situated outside the individual's perception of control, i.e. barriers or facilitators, paired with the perceived extent to which it is important to have such control (Ajzen, 1991; Montaño & Kasprzyk, 2008). In this particular study, we restrict ourselves to the issue of self-efficacy, albeit labeling it as perceived behavioral control. Self-efficacy refers to *'one's capabilities to organize and execute a course of action to produce certain attainments'* (Bandura, 1994, p. 3). Before exercising an action with a valued, reinforcing outcome, people assess their ability to perform the situated behavior with its specific demands, in conjunction with the feasibility of successfully performing it. These constructed beliefs affect the reasoning that precedes as well as follows upon behavior; it mediates cognitive, affective and motivational processes (Bandura, 1993). The sources of self-efficacy are manifold. It is built by successful enactive experience, by vicarious experiences through social models and social comparison, by verbal persuasion (e.g. through verbal feedback) and by interpreting personal physiological and affective states (Bandura, 1994).

The importance of self-efficacy in the domain of technology and information system acceptance and usage has been amply demonstrated, rendering it a crucial factor in the uptake of new media technologies (e.g. Durndell & Haag, 2002; Fagan, Stern, & Wooldridge, 2004; Hsu & Chio, 2004). This is no different for technology in education. Indeed, variance in computer self-efficacy remains a focal issue, as it explains differences in both learning outcomes and processes (Meelissen, 2008; Moos & Azevedo, 2009). As such, we consider self-efficacy a key issue in this study, especially given the perhaps overly enthusiastic stance towards the tablet as the

epitome of a practical and easily accessible technology (Ant Ozok, Benson, Chakraborty, & Norcio, 2008).

H3: Perceived behavioral control positively explains use intention and actual use at each wave.

The longitudinal component: pre- versus post-adoption

As amply demonstrated in empirical applications of acceptance models, attitude, subjective norm, and perceived behavioral control play a central part in explaining behavioral intention and actual use. However, an obvious limitation of purely cross-sectional designs is the neglect of the potential over-time changes of these factors' roles. This inevitably obfuscates researchers' understanding of technology adoption, as it is a dynamic process. For example, prior research on information systems' continuance has indicated that attitude, a core component (Yang & Yoo, 2004), is likely to differ over time (Bhattacherjee, 2001). A plausible explanation, partially supported by empirical research (Karakhanna, Straub, & Chervany, 1999), is that pre-adoption attitudes are usually based on second-hand information and perhaps give rise to inaccurate or unrealistic beliefs, whereas post-adoption attitudes are rooted in actual first-hand, repeated experience. Continued follow-up on the development of such a key variable is of the utmost importance to assure adoption continuance. Still, as Venkatesh and Morris (2000) argue, supported by evidence from both technology acceptance studies and related psychological research, attitudinal components appear significant determinants of intention, even after weeks of experience. Furthermore, despite reaffirming the important status of subjective norm, they presume that its influence drops as other people's norms are internalized, especially when they are consistent with the own experiences. Equally important though, and unfortunately under-researched, is the over-time interplay

between technology acceptance factors. For that reason, following-up on the cross-sectional hypotheses, our study adds four more longitudinal hypotheses, inquiring possibly reciprocal causal relations between attitude and perceived behavioral control on the one hand, and attitude and subjective norm on the other.

A first issue is the role of attitude, in conjunction with perceived behavioral control. As mentioned, we especially focus on self-efficacy, i.e. the perceived competence to handle a tablet as a learning tool. Various studies have indicated positive correlations between learners' attitude or expected outcomes towards learning tools and the perceived mastery of them (Bates & Khasawneh, 2007; Moos & Azevedo, 2009; Ong & Lai, 2006). Although these studies assume causality by self-efficacy, giving rise to a positive attitude, this has not been unequivocally verified. Of course, as an assumption, this makes sense, albeit that a reversed trace of causality might be equally plausible. A learner could identify the merits of a tool, and foster a positive attitude towards it while not being able to operate it yet. Likewise, a sense of mastery, but a skeptical stance could over time turn into a positive attitude, as the perceived skills to handle the tool are at hand and the barriers to use it are low. As such, we propose the following two hypotheses:

H4a: An earlier positive attitude serves as a substrate to develop a stronger perceived behavioral control.

H4b: A stronger perceived behavioral control supports the later development of a positive attitude.

Considerable research on technology acceptance has indicated social pressure, both by peers and hierarchical superiors as a strong explanatory factor in explaining the intention and actual uptake of innovations (Venkatesh & Morris, 2000). As yet demonstrated, developments in educational technology form no exception. Despite

scarcity in research on the over-time interplay between subjective norm and attitude on technology in education, there are nonetheless precedents. For instance, a study employing the TAM model found that earlier measures of subjective norm positively explain future attitudes, and vice versa, after controlling for measurement stability (Sivo et al., 2004). It appears that a positive attitude at one point renders students more susceptible to social influence, while a feeling of social influence also predicts an onwards-positive attitude. The former is likely due to a confirmation bias, i.e. the tendency to mainly select and be attentive of belief-confirming information (Nickerson, 1998). When a positive attitude is maintained, confirming information is more positively appraised. On the other hand, the reverse hypothesis hints that positively oriented teachers, together with the school board, would pass this belief on to the students. Although it is most unlikely that all teachers welcome the tablet device to an equal extent, it must be noted that before taking the decision to take the leap into implementation, wide support at teacher level was a prerequisite. Hence, we presume that the general teacher position to and communication concerning the school-wide adoption was generally neutral to favorable. Still, in literature, it is assumed that in the first stages of (forced) adoption, subjective norm has a much stronger influence on the uptake than later on (Venkatesh & Morris, 2000). If the technology performs well, like peers and superiors advocated, it is much more likely that these experience-matching beliefs are internalized.

In this study, we already assumed that due to the forced nature of the implementation, subjective norm would play a fundamental role. Hence, we expect to encounter similar results as Sivo and colleagues (2004):

H5a: An earlier positive attitude renders students susceptible for subjective norm at a later time.

H5b: A stronger sense of subjective norm at an earlier time supports the development of a positive attitude later on.

Method

Procedure

The present study took place in a secondary school in Flanders, Belgium's Dutch-speaking region. This school comprises three types of secondary education: general, technical, and vocational. Since the beginning of the school year in September 2012, all students and teachers have been obliged to adopt a personal tablet device for schoolwork, both during and after school hours. As such, the school directors fully subscribed to the ideology of technology to support dynamic and individual learning, using means close to the teenagers' life worlds. Three waves of data collection were organized (Figure 2). A first one, during the first week of school in September 2012 focused on pre-adoption expectations of using the device for school. The second round of data collection took place in November 2012. At that point, the devices had been used daily during classes and for homework and studying. Evidently, this wave was directed at capturing post-adoption experiences. Finally, a third wave was administered in March 2013. At this stage, the students not only acquired experience in class, they had also used their devices to study for the midterm exams in December 2012, of which the grades were at time been disseminated. Again, experiences were the focal point of attention. It is important to keep in mind that the adoption of tablet devices in the studied school was organized with the goal to absolutely minimize the use of paper textbooks and exercise sheets in favor of digital ones. Moreover, next to a digital learning environment, various add-on interactive applications were introduced in the classrooms. Hence, the reach and consequences for everyday class practices of this radical innovation should be deemed substantial,

as these devices are used in every class for a broad diversity of tasks throughout the entire day.

< Insert Figure 2 >

The data were collected through online questionnaires, filled out by the students on their personal tablet during class hours. Participation was highly encouraged, albeit not mandatory. At the beginning of each questionnaire, students were asked to identify themselves, in order to allow a coupling of sample moments. Nevertheless, anonymous data processing and reporting was ensured at all time. Despite efforts to incite as many students as possible to take part in the study, there is a substantial attrition, which is unfortunately a common phenomenon in multiple-wave longitudinal studies (Goodman & Blum, 1996). At the first wave, 678 students participated (42% boys, 58% girls, M_{age}=14.73, SD_{age} = 1.98), which was further reduced to 82% and 52% in the second and third wave respectively. Hence, the final sample comprised 352 students (39% boys, 61% girls, M_{age}=14.36, SD_{age} = 2). Possible reasons for this dropout, among manifold others, are absences, time constraints, errors in identification data provided by students, and of course discontent with the study or participation fatigue. However much more problematic for the study's validity, would be a reluctance towards the subject matter of tablets at school. Consequently, before testing the proposed hypotheses, a dropout analysis appeared an absolute prerequisite in order to grasp potential problematic patterns in attrition (cf. infra).

Measures

The following paragraphs document the applied measurement instruments, summarizing descriptive statistics and psychometric properties (see Table 1). Full

enumerations of items, adapted from Taylor and Todd (1995), are found in the article's Appendix section.

Attitude (A) *(towards the iPad as a learning tool)* was measured by a double four-item instrument, rated on a five-point Likert scale ranging from *'completely disagree'* to *'completely agree'*. All four items were weigthed by the extent to which the attitudinal beliefs are considered important (i.e. five-point Likert scale ranging from *'not at all important'* to *'very important'*). This measure demonstrates good internal consistency across all three waves.

Subjective Norm (SN) comprised a double measure, in total comprising four items. The first two items inquire the extent to which (a) teachers and (b) the school board considers the iPad as a useful learning tool, rated on a five-point Likert scale, ranged *'completely disagree'* to *'completely agree'*. Both items were weighted by the extent to which these two sources of subjective norm are considered important (i.e. five-point Likert scale ranging from *'not at all important'* to *'very important'*). Both measures correlate substantially across waves, and are hence averaged.

Perceived Behavioral Control (PBC) in essence comprises a measure of self-efficacy to use the iPad for school. As with Attitude and Subjective Norm, both beliefs and evaluations were measured, using the latter to weigh the former. That is, first, four items probed into efficacy beliefs, while second, these beliefs were evaluated in terms of importance. The four weighted efficacy items demonstrate a satisfactory internal consistency at all three waves

Intention to use (I) was measured at the first wave in September 2012. A six-item measure inquired how often students estimated the prospective use of their iPads for school purposes, both at school and at home (cf. Appendix). The items were rated

on a five-point scale, ranging from *'never'* to *'very often'*. The instrument shows good internal consistency.

Actual use (U) was measured at the second and third wave in November 2012 and March 2013 respectively. It inquired retrospective estimations of actual use. At the second wave, the frame of reference was the period between the start of the school year and questionnaire administration. At the third wave, this frame ranged from the period after the midterm exams until questionnaire administration. The instrument draws upon the very same items as intention to use, employing the exact same rating scale. Both at the second and third wave, the measures demonstrate a satisfactory internal consistency.

< Insert Table 1 >

Results

Dropout analysis

As mentioned in the procedure section, this study suffered from substantial dropout rates, in the end retaining 52% of the initial respondent pool. As such, there is an apparent need to verify whether this attrition is contingent with a priori expectations towards the subject matter (Goodman & Blum, 1996). In order to shed light on this matter, a multinomial regression model is computed, employing attitude, subjective norm, perceived behavioral control, and use intention measured at the first wave as independent variables, and dropout at the second or third wave as a nominal dependent variable. This results in a well-fitting model ($\chi^2(8) = 24.71$, $p < .005$), however explaining five per cent Nagelkerke pseudo-R^2. The results, summarized in Table 2, indicate that subjective norm accounts for dropout in the both the second and third wave, whereas attitude only does in the third wave. More specifically, a sense of obligation by teachers and directors increased the odds to keep on participating in the

study, while a priori negative attitude explains attrition between the second and third wave.

< Insert Table 2 >

A subsequent analysis binary regresses the dropout between wave two and three, explaining 4 per cent of the Nagelkerke pseudo-variance ($\chi^2(4) = 10.21$, $p < .05$; Table 3). This shows again that a subjective norm to use the tablet is paired with an on-going participation in the study.

< Insert Table 3 >

These small, yet non-surprising effects do not seem to endanger the validity of claims derived from the final sample, provided that a minimal restriction of range by dissatisfied students is probable. Moreover, reprising Table 1, we point to the very similar dispersion within measures at all three waves.

Cross-lagged longitudinal path analysis

To test the study's proposed hypotheses, a path model was computed, employing all three waves' measurements. More specifically, per wave, paths from attitude, subjective norm and perceived behavioral control toward either use intention of actual use were modeled.

Next, to test the longitudinal hypotheses, the necessary paths for a cross-lagged analysis were included (Burkholder & Harlow, 2003; E. Ferrer & McAdrle, 2003). First, these comprise auto-regression stability paths, regressing a next wave's measure onto its previous measurement. Second, a cross-lagged regression is added, which is in generic terms the effect of a variable X_{T1} at first time on a variable Y_{T2} at a second later time, whereas the same logic applies for Y_{T1} and X_{T2}. If such paths appear significant, it represents a trace of causality. Furthermore, two types of covariance were additionally modeled. First, we modeled (residuals') covariances

between attitude, subjective norm, and perceived behavioral control at all separate waves. Second, first wave variables were allowed to covary with the corresponding variables' error terms at the third wave. The rationale behind this is that these measures might share? variance that is unaccounted for by their second wave measurements. All of these co-vary significantly. However, their immediate relational structures are not a point of attention in the present study.

As such, 62 free parameters require estimation. Taking into account the rule-of-thumb of including at least five cases per estimated parameter (Kenny, 2012), the present sample of 352 appears sufficient. The model, based on the correlations presented in Table 2 and graphically presented in Figure 3, yields a good fit ($\chi^2(28) = 46.77$, $p < .05$, TLI = .97, CFI, .99; RMSEA = .04, *p*close = .66).

< Insert Figure 3 and Table 4 about here >

There is mixed evidence for the first hypothesis (H1), proposing significant paths from attitude to (intention to) use. In the first wave, focusing on pre-adoption expectations, attitude appears a strong factor in explaining intention of use. Later on, during the school year, attitudes do not account for variance in actual use. Interestingly, the indirect effects of pre-adoption attitude through use intention on actual use at the second and third wave are consistently significant ($\beta = .22$, $p < .001$ and $\beta = .13$, $p < .001$, respectively). This implies that a priori positive attitudes persist to shimmer through, even months later.

In second instance, we hypothesized an effect of subjective norm on (intention to) use (H2). This hypothesis is consistently confirmed: direct effects are noticed at all three waves. Furthermore, there are no traces of indirect effects between waves.

The third hypothesis proposed an effect of perceived behavioral control on (intention to) use (H3). This is only the case in the second wave. However again, this

effect indirectly explains actual use at the third wave (β = .13, $p < .005$). Due to close and regular contact with the school at various occasions, we inferred this effect mainly has to do with technical issues with software applications and students' difficulties to master to the tablet as a learning instrument, rather than an entertainment device (see discussion).

The first causal hypothesis *H4a* predicted a positive attitude to give rise to a stronger sense of perceived behavioral control. This is confirmed at all times. Next, *H4b* predicted that a stronger perceived behavioral control would give rise to developing a more positive attitude. This hypothesis is only supported between the second and third wave.

Furthermore, *H5a*, expecting an earlier attitude to render students more susceptible for subject norm later on is consistently confirmed. However, *H5b*, predicting a stronger sense of subjective norm to give rise to a more positive attitude later on finds no support whatsoever. Nevertheless, when dropping the stability paths between subjective norm between both waves and calculating the indirect paths of subjective norm at an earlier point on use at a later point, we find these effects yield significance. The magnitude of the effect is negligible between the first and second wave (β = .03, $p < .05$), but bears some minor substance between the second and third wave (β = .10, $p < .005$). We will specifically reprise these findings in the discussion.

Table 5 concisely summarized the evidence for the seven proposed hypotheses, as found in the present study.

< Insert Table 5 >

Discussion

The objective of this case study was to adequately model the over-time acceptance of a full-scale implementation of the tablet as a learning device, both at

school and at home. As this research topic is emergent, such research is to our knowledge unprecedented. As argued, we focus on the longitudinal character of data collection, as commonplace cross-sectional efforts are informative, although they might be equally misleading at the same time. As adoption is a dynamic process, evolving through phases of pre- and post-adoption, it is not always clear where to position a cross-sectional effort. In contrast, a longitudinal effort like this one sheds light on this evolution, emphasizing its relevance. Our appropriation of the Theory of Planned Behavior has proven sufficiently sensitive to grasp the evolving sentiments at hand. As such, the bigger picture is aptly drawn, which in turn incites goal-directed and properly informed follow-up research. In the following paragraphs, this evolution is further discussed.

However, before discussing the results, we need to warn for a, albeit minor, restriction of range, caused by the attrition throughout the different waves. Students that displayed a more negative stance from day one were less likely to maintain participation whilst those who felt a stronger subjective norm, i.e. by teachers and the school board, are relatively overrepresented. Still, as argued in the dropout analysis section, the effects of attrition are rather small, so we were nevertheless able to proceed with a meaningful interpretation of the findings. As such, meticulous analyses of attrition patterns are an indispensible in longitudinal designs, and especially in interpreting their results.

In general, our findings partially mirror the proposed hypotheses. At the beginning of the school year, in September, it was clear that students had fairly positive attitudes, which was the strongest explanatory factor of using the tablet for school, throughout the year. At that point, there was no significant effect of perceived behavioral control, hinting to the perception that there were no substantial

obstructions in handling the device for learning practices. As expected, a minor sense of obligation was perceived, as subjective norm – reflecting the urge by teachers and the school board – rendered a minimal, yet significant effect.

Three months later, in November, the picture had slightly changed. The attitude measure at that point did not explain any unique variance in usage, despite a significant zero-order correlation. Nevertheless, we observed a significant indirect effect through the autoregressive stability path between intention and use by the attitude measured at the first wave. This suggests that the attitude prior to adoption proved accurate to some extent. Interesting though, is the direct effect of perceived behavioral control. Three months post-adoption, we learned from teachers and students that the implementation yielded some problems of variable nature. First, there were technical issues with the application used on the tablets (e.g. crashes, down-time, usability issues). Second, it proved more difficult than expected to use the device in a school context (e.g. incorporation in class, cope with distractions such as social media and games). Considering previous literature, these issues fit the evident struggles of implementing the tablet as a new technology (Henderson & Yeow, 2012; Ifenthaler & Schweinbenz, 2013). Next to considerable efforts to solve technical issues, the teaching staff took on a more restrictive stance towards these issues, while continuously motivating students to persist. This enables us to understand the more strongly felt subjective norm at that point. This is consistent with information systems literature that argues that in theory the influence of subjective norm drops and gets internalized (Venkatesh & Morris, 2000), on the condition that everything works properly, as advocated. In this particular instance, this was absolutely not the case.

Finally, in March, the picture changed again. Both effects of attitude and perceived behavioral control disappeared, while the direct effect of subjective norm

toned down. At this point, we see that the TPB measures, despite continuously significant correlations, no longer explain use. Their effects are cancelled out by use at the previous wave, as the autoregressive stability path proved more substantial. This is plausibly explained through literature on habit formation, stating that repeated satisfactory behavior under stable circumstances eventually leads to habit build-up, toning down the effects of attitudes and subjective norm (Ajzen, 2002; Ouelette & Wood, 1998). Although previous behavior is not an undisputed index of habit (i.e. it is too restrictive, not fully representing it as the mental construct it is) (Verplanken, 2006), it does offer an indication that the use of the tablet at that point got internalized as a routine practice at school. At that point, conscious deliberations of attitude and perceived behavioral control were not that important anymore. This finding emphasizes the problematic nature of cross-sectional designs, especially when it comes to the timing of data collection. Our results clearly show an evolution towards habituation, which renders the TPB building blocks that dominantly draw upon salient cognition fairly obsolete and even deceptive. Both in theoretical and methodological terms, post-adoption research efforts should therefore focus on the habit-goal interface (i.e. issues of automaticity; Wood & Neal, 2007).

The present study however also takes into account the interplay between TPB measures over time. In that respect, there is a strong support for the assumption that a positive attitude at a prior instance gives rise to the development of a stronger perception of behavioral control. Students who have a favorable position towards the tablet as a learning tool are more prone to develop their sense of skill. Our results strongly indicate the prominence of perceived behavioral control. Although it is commonly assumed that tablet devices are easy to use, this might be so for entertainment purposes, but not necessarily for educational ends – next to the issue of

reduced functionality of the applications. As such, there should be a constant attention to support the necessary skill sets to handle both device and content. This is further amplified by the finding of a cross-effect of perceived behavioral control on attitude between the second and third wave. Those who felt more efficacious in November, during the aforementioned difficult period, came out with a more positive attitude at the end. It should however be noted that at that point, attitude was no longer a key explanatory variable.

Finally, subjective norm, which is a severely under-researched issue when it comes to students' uptake of technology in education, proved a robust explanatory variable at each wave. This reaffirms TPB as an especially suitable model to capture technology adoption. Interestingly, a positive attitude at a previous time gives rise to a greater susceptibility to subjective norm at a later point. This however equally implies that a negative attitude brings about a relative disengagement with the teaching staff. Moreover, a restrictive inclination to use the device does not support the build up of a positive attitude. As such, it is advisable to keep investing in the formation of positive attitudes without adopting too much of a coercive style. If there were accordance with the literature, we would have expected an internalization of subjective norm as soon as most of the problems got fixed and the implementation would start to pay off (i.e. between second and third wave). Still, there is no effect of (the albeit stronger) subjective norm at the second wave on the attitude at the third wave. What we do notice is a significant indirect effect of subjective norm on use at the third wave, mediated by use at the second wave, combined with a drop in the effect of subjective norm at the third wave. Interestingly, this does hint towards an implicit internalization as argued in the context of long-term acceptance in literature (Venkatesh & Morris, 2000).

In conclusion, this study demonstrates the value of the TPB framework to study the uptake of digital technologies in various sites of everyday life, albeit with the necessity to embrace a longitudinal cross-lagged framework that allows tracing causal paths between crucial factors. As such, this research is of interest for academics (i.e. on a practical methodological as well as a conceptual level, as it emphasizes the need for a dynamic approach that eventually includes automaticity, rather than a static one that limits itself to salient factors), next to a contribution with regards to an important innovation in education technology, as opposed to other technological means. This opens possibilities for comparative meta-analyses in the future. Concerning non-academic purposes (i.e. education policy and practitioners), we learned that – at least for the school we studied – a full-scale introduction of tablets is a thorny endeavor. Students have naturally high expectations towards using trendy technology at school, only covering a part of what the innovation might provide. At the same time, students tend to foster positively distorted perceptions of personal skill. Equally, it should be considered that especially in early innovation stages, technology tends to fail. Toning down expectations and considering a gradual implementation, paired with sufficient support could alleviate much of these problems. In the end, we need to stress the necessity of open, non-coercive communication. Acting too forceful does not support the necessary, bottom-up compliance. On the contrary, it might undermine the teaching staff's position.

Still, research like this is only an entry point in the phenomenon. Hence, we emphasize the need for intensive follow-up research that allows for mapping the dynamics and problems of educational technology adoption (i.e. ethnographic and quasi-experimental approaches). Moreover, a key issue remains the actual (incremental) learning effect of using such technology.

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Table

Table 1. The study's measures' means, standard deviations (min = 1, max = 5) and Cronbach's alpha internal consistency measures. The measures were calculated each wave separately, not taking into account the attrition. [+] As these were two-item measures, Pearson zero-order correlations are reported instead.

	Wave 1			**Wave 2**			**Wave 3**		
	M	*SD*	α	*M*	*SD*	α	*M*	*SD*	α
A	3.46	1.02	.92	3.19	1.12	.93	3.18	1.10	.93
PBC	3.73	0.84	.88	3.76	0.90	.90	3.79	0.87	.90
SN	2.85	0.92	.71[+]	2.63	0.92	.67[+]	2.58	0.93	.70[+]
I	3.87	0.66	.83	-	-	-	-	-	-
U	-	-	-	3.94	0.71	.84	3.74	0.77	.87

Table 2: Multinomial dropout regression analysis explaining dropout at the second and third wave by first wave measures. Initial participation is employed as reference category. * $p < .05$, ** $p < .005$

	Dropout after Wave 1				**Dropout after Wave 2**			
	B	*SE*	Wald	Exp(B)	B	*SE*	Wald	Exp(B)
Intercept	.03	.69	.00	-	-.02	.60	.00	-
A_{W1}	-.13	.13	.96	.88	-.22	.11	4.01*	.80
PBC_{W1}	.16	.14	1.24	1.17	.06	.12	.25	1.06
SN_{W1}	-.08	.03	1.58**	.92	-.06	.02	6.51	.95
I_{W1}	-.01	.12	.00	.99	.14	.10	1.75	1.15

Table 3: Binary dropout regression analysis explaining dropout between the second and third wave by second wave measures, containing only wave two participants. * $p < .05$

	Dropout between Wave 2-3			
	B	*SE*	Wald	Exp(B)
Intercept	-.15	.71	.05	.86
A_{W2}	-.09	.12	.53	.92
PBC_{W2}	.10	.16	.35	1.10
SN_{W2}	-.08	.03	6.31	.93*
U_{W2}	-.04	.19	.04	.96

Table 4: Zero-order Pearson correlation matrix of the model variables at all three waves. All coefficients are significant at $p < .05$.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1. A_{W1}	-										
2. PBC_{W1}	.51	-									
3. SN_{W1}	.39	.32	-								
4. I_{W1}	.45	.24	.29	-							
5. A_{W2}	.63	.38	.29	.30	-						
6. PBC_{W2}	.41	.51	.27	.16	.57	-					
7. SN_{W2}	.28	.23	.47	.16	.43	.46	-				
8. U_{W2}	.24	.21	.23	.35	.38	.43	.41	-			
9. A_{W3}	.56	.36	.26	.20	.76	.53	.37	.25	-		
10. PBC_{W3}	.33	.48	.24	.12	.45	.56	.39	.29	.57	-	
11. SN_{W3}	.28	.22	.42	.17	.37	.33	.57	.33	.47	.49	-
12. U_{W3}	.12	.16	.14	.25	.18	.28	.25	.52	.21	.26	.33

Table 5: Summary of the study's hypotheses and their supporting evidence.

Hypothesis	**Evidence**		
	W1	W2	W3
H1: Attitude positively explains use intention and actual use at each wave.	✓	×	×
H2: Subjective norm positively explains use intention and actual use at each wave.	✓	✓	✓
H3: Perceived behavioral control positively explains use intention and actual use at each wave.	×	✓	×

	W1-2	W2-3
H4a: An earlier positive attitude serves as a substrate to develop a stronger perceived behavioral control.	✓	✓
H4b: A stronger perceived behavioral control supports the later development of a positive attitude.	×	✓
H5a: An earlier positive attitude renders students susceptible for subjective norm at a later time.	✓	✓
H5b: A stronger sense of subjective norm at an earlier time supports the development of a positive attitude later on.	×	×

Attitude

(belief; 'completely disagree' to *'completely agree')*

To what extent do you agree with the following statements?

- Using the iPad for school is fun
- Using the iPad for school is enjoyable
- It feels good to use the iPad for school
- It is interesting to use the iPad for school

(evaluation of desirability; 'not at all important' to *'very important'*)

How important is it that…

- Using the iPad for school is fun
- Using the iPad for school is enjoyable
- It feels good to use the iPad for school
- It is interesting to use the iPad for school

Subjective norm

(normative belief; 'completely disagree' to *'completely agree')*

To what extent do you agree with the following statements?

- My teachers think the iPad is useful for school work
- My school's board of directors think the iPad is useful for school work

(motivation to comply; 'not at all important' to *'very important')*

How important is it…

- To do what my teachers think I should do
- To do what my school's board of directors think I should do

Perceived behavioural control

(control belief; 'completely disagree' to *'completely agree')*

To what extent do you agree with the following statements?

- It is easy to learn how the use the iPad for school
- The directions to use my iPad for school are simple
- It is easy for me to become an advanced iPad user
- The iPad is straightforward to use for school

(perceived facilitation; 'not at all important' to *'very important')*

How important is it that…

- It is easy to learn how the use the iPad for school
- The directions to use my iPad for school are simple
- It is easy for me to become an advanced iPad user
- The iPad is straightforward to use for school

Intention

How often do you think you will use the iPad (Never – Very often)

- I will use the iPad during classes at school
- I will use the iPad for assignments at school
- I will use the iPad for homework
- I will use the iPad to study
- I will use the iPad to contact my classmates about school work
- I will use the iPad to contact my teachers about school work

Use

How often have you use the iPad since (a) the beginning of the school year, (b) this semester (Never – Very often)

- I have used the iPad during classes at school
- I have used the iPad for assignments at school
- I have used the iPad for homework
- I have used the iPad to study
- I have used the iPad to contact my classmates about school work
- I have used the iPad to contact my teachers about school work

Figure 1

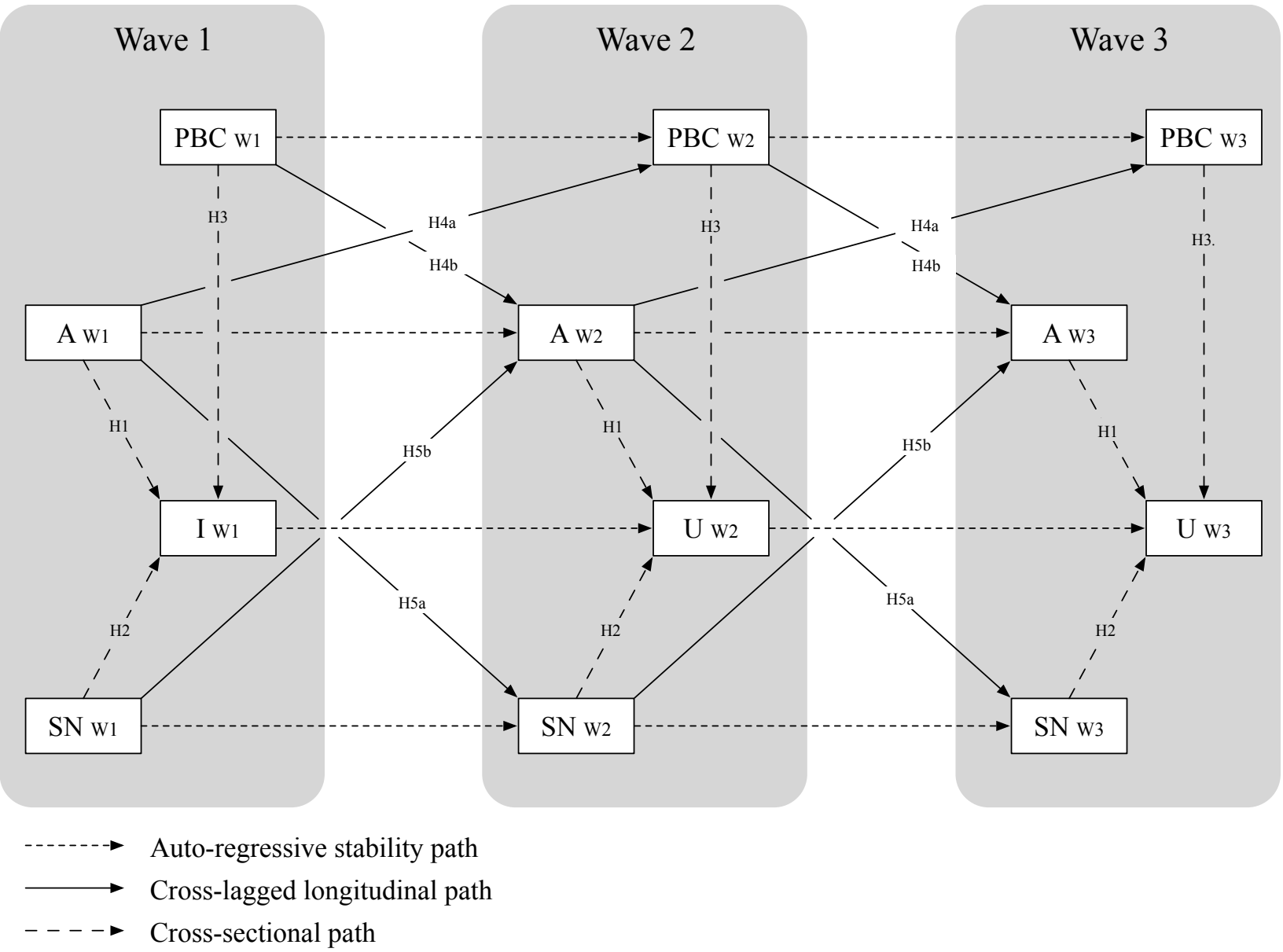
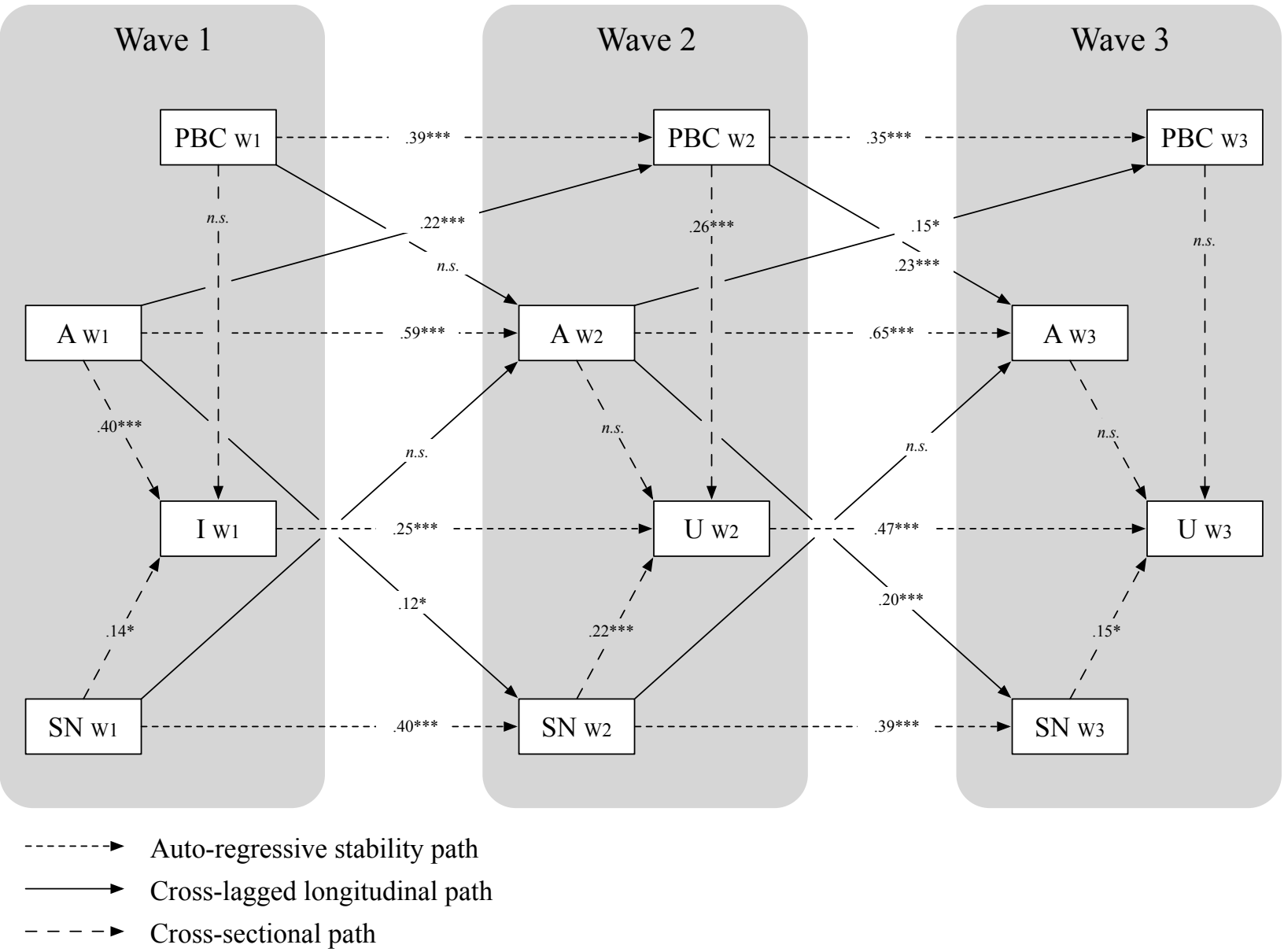

Wave 1
Wave 2
Wave 3
PBC W1
PBC W2
PBC W3
A W1
A W2
A W3
I W1
U W2
U W3
SN W1
SN W2
SN W3
H1
H2
H3
H3.
H4a
H4b
H5a
H5b
Auto-regressive stability path
Cross-lagged longitudinal path
Cross-sectional path

Figure 2


Wave 1
September 2012
Expectation
(Pre-Adoption)
Wave 2
November 2012
Experience A
(Post-Adoption)
Wave 3
March 2013
Experience B
(Post-Adoption)

Figure 3


Wave 1
Wave 2
Wave 3
PBC W1
PBC W2
PBC W3
A W1
A W2
A W3
I W1
U W2
U W3
SN W1
SN W2
SN W3
.39***
.35***
.22***
.26***
.15*
.23***
n.s.
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.12*
.20***
.14*
.22***
.15*
.40***
.39***
Auto-regressive stability path
Cross-lagged longitudinal path
Cross-sectional path